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FIELD TEST OF ACEPHATE AGAINST TWO DOUGLAS-FIR CHRISTMAS TREE PESTS

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Abstract

When acephate was applied to Douglas-fir Christmas trees before and after bud burst, it significantly reduced the Douglas-fir needle midge *(Contarinia pseudotsugae)* population. The same treatments did not significantly reduce the summer generation of Cooley spruce gall aphid *(Adelges cooleyi)* population but caused increased populations in the winter generation. Symptoms of phytotoxicity occurred on trees treated after bud burst.

KEYWORDS: Insecticides (-forest pests, needle midge, *Contarinia pseudotsugae*, Cooley spruce gall aphid, *Adelges cooleyi*, Christmas tree crops, Douglas-fir, *Pseudotsuga menziesii*, acephate, phytotoxic effects (pesticide).

Two common insect pests of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) Christmas trees in western Oregon and Washington are the Douglas-fir needle midge (*Contarinia pseudotsugae* Condrashoff)[1/] and the Cooley spruce gall aphid (*Adelges cooleyi* (Gillette)). Neither insect kills the tree, but both damage new needles and thus affect tree appearance and value.

C. pseudotsugae is the more serious of the two pests. The adult emerges from the soil in the spring and lays eggs on expanding buds and needles. Newly hatched larvae mine into the new needles, and yellow or purple galls form at the point of attack. About November, the galled needles usually turn brown and fall from the tree. Defoliation in some years can be severe enough to make nearly every tree in a plantation unmerchantable (Condrashoff 1962).

A. cooleyi is normally the less damaging pest but can cause a large number of unsightly trees. Injury stems from emerging nymphs of the overwintering generation which feed on new growth. The most severe damage occurs on the young, tender needles just out of the buds. These needles develop severe crooks and chlorotic blotches at the feeding sites (Crooke 1960). Heavy attacks can also reduce twig growth and cause premature needle fall.

Growers have recently been reducing damage to new growth by applying the insecticide endosulfan (Nagel 1968; Saunders and Barstow 1970). One application at the start of bud burst has been effective against both pests, but the high cost and safety hazards of the material make alternative insecticides desirable.

This paper describes a 1976 field experiment in Oregon which tested the efficacy of the insecticide acephate against these two Christmas tree pests. Acephate was selected because it was likely to be safer and cheaper to apply than endosulfan, and because the reported systemic qualities seemed applicable to the biology of the two pests we wanted to control.

[1/] *Contarinia pseudotsugae* Condrashoff is the principal member of a three-species complex. The other two species, *C. constricta* Condrashoff, and *C. cunicular* Condrashoff, are unimportant in western Oregon and Washington.

Materials and Methods

The general framework of the test was to determine if acephate would contol midges and aphids when applied to individual trees at three doses both before and after bud burst. The test was conducted on a 2-acre (.8-ha) Christmas tree plantation 15 miles (24 km) south of Corvallis, Oregon. Moderate populations of both the needle midge and the gall aphid were observed there in 1975 and 1976. All trees were sheared Douglas-fir grown in rows and spaced at 6-foot (1.8-m) intervals. The trees were 6 years old and ranged in height from 4 to 7 feet (1.2 to 2.1 m).

The experimental design was two spray periods and 4 treatments per spray period. Times and treatments were then randomly assigned to 240 randomly selected trees--120 trees per spray period and 30 trees per treatment. The first spray period was on May 3, just before most of the trees had burst buds. The second spray period was on May 11, when about 60 percent of the trees had burst buds. A scheduled third spray at 100 percent bud burst was cancelled because of phytotoxicity in the second treatment.

Thirty unsprayed trees served as a check in each spray period. Each of the remaining 90 trees was treated with 1 pint (473 ml) of insecticide solution delivered through a nozzle held directly above the treated tree. The amount of acephate (Orthene 75 S) in 1 gal. (3 785 ml) of water of the 3 insecticide treatments was: Low - 0.05 lb AI (22.5 g); Medium - 0.1 lb AI (45.5 g); and High - 0.2 lb AI (92.7 g). Spray drift to adjacent trees was avoided by enclosing the treated trees at the time of treatment within a portable, plastic-covered screen (fig. 1).

Figure 1--Post bud burst treatment of Douglas-fir Christmas tree with acephate. Portable, plastic-covered screen protected other trees from contamination.

It was partly cloudy on the day of the first spray period, and the temperature was 68°F (20°C). Heavy rain showers occurred in the area about 40 hours after the spray was applied. Temperature on the day of the second spray period was 72°F (22°C), and the sky was clear. The first rain was recorded 9 days after spraying.

Treatment effectiveness was evaluated by comparing pest population densities on unsprayed check trees with those on treated trees. For *C. pseudotsugae*, the number of galls was counted in late July on six 5-in. (12.7-cm) twigs clipped from the midcrown of each tree. The sample procedure was the same for *A. cooleyi* except that the aphids were counted in early July on four twigs. The average number of needles in each sample unit was about 700 for the midge and 500 for the aphid. A larger sample unit was selected for midges because it appeared the within-tree sample variation would be greater.

In the spring of 1977, a quick classification system was devised to reevaluate *A. cooleyi* populations on plot trees. The classification established 5 population categories. Guidelines used in the classification were: 1 = no aphids or only occasional aphids, 2 = 1 aphid per 100 needles, 3 = 10 to 50 aphids per 100 needles, 4 = 1 aphid per needle, and 5 = 5 or more aphids per needle. Populations falling between guideline figures were placed in the category to which they appeared closest.

Data were statistically analyzed according to standard procedures for an experiment with a completely randomized factorial design. With one exception, the established probability level for statistical significance was $P \leq 0.01$. With the midge, it was necessary to use logarithmic transformations on the data to equalize variances within treatments.

Results

Acephate reduced Douglas-fir needle midge populations when applied either before or after bud burst (table 1.) In both periods, there was a significant decrease in midge populations with increasing insecticide dose. When spray dates were compared, the population reduction for the pre-bud burst treatment was significantly greater than for the treatment at 60 percent bud burst. Also, a test of interaction showed that the pre-bud burst treatment was progressively and significantly more effective with increasing dosage than the treatment at 60 percent bud burst.

Acephate was not effective against the spring generation of *A. cooleyi*. The data, summarized in table 2, suggest a trend toward population reduction; but differences were not statistically significant. When the winter generation was checked a year after treatment, it was found that the aphid population was significantly greater on treated trees than on untreaed trees (table 3). Also, the trees treated at 60 percent bud burst had a significantly ($P<0.05$) greater population than trees treated before bud burst.

Table 1--*Mean numbers of* C. pseudotsugae *per tree on acephate treated and check trees*

Spray period	Treatment dose				Mean[1/]
	Check	Low	Medium	High	
Pre-bud burst	75.113	0.163	0.007	0.006	0.153
Post-bud burst	96.351	.944	.444	.007	.738
Mean[1/]	85.030	.392	.057	.007	--

1/ Means will not balance because they are based on untransformed mean logs.

Table 2--*Mean numbers of* A. cooleyi *per tree on check trees and trees treated with acephate (summer generation, 1976)*

Spray period	Treatment dose				Mean
	Check	Low	Medium	High	
Pre-bud burst	58.2	53.8	41.0	23.4	44.1
Post-bud burst	40.0	36.3	36.8	34.6	36.9
Mean	49.1	45.0	38.9	29.0	--

Table 3--*Mean population of* A. cooleyi *per tree based on classification of five population categories*[1/] *(winter generation, 1977)*

Spray period	Treatment dose				Mean
	Check	Low	Medium	High	
Pre-bud burst	1.53	2.63	2.70	2.33	2.30
Post-bud burst	1.53	2.97	3.20	2.50	2.55
Mean	1.53	2.80	2.95	2.41	--

1/ 1 = No population, 2 = light population, 3 = medium population, 4 = heavy population, 5 = very heavy population.

A phytotoxic reaction was observed on trees that had flushed in the 60 percent bud burst treatment. New needles were burned at all three dosages. Damage was most severe at the high application rate, resulting in injury to 10-50 percent of the new needles. Damage was also conspicuous at the low dose, though less than 1 percent of the needles were affected.

Most damaged needles were on the tops of the new shoots and at the basal ends. Some needles turned completely red, but usually only the distal 1 to 2 cm faded. First signs of redness appeared about 7 days after spraying and the damage was most noticeable after about 1 month. By September, most of the burned needles had fallen from the trees.

A slight symptom of phytotoxicity was also observed associated with the treatment before bud burst. Trees treated with the high dose of acephate developed a distinct yellowing at the distal 2 to 3 mm of the needles. This condition was still apparent in March 1977.

Discussion

The key findings of this test were that acephate (1) controlled midges and (2) was effective as a systemic insecticide when applied before bud burst. The reason the treatment prior to bud burst was more effective than treatment at 60 percent bud burst appears related to the infestation characteristics of the midge. Aborted attacks were observed to be quite common in both treatments, suggesting that most control occurred as the larvae first began to bore into the needles. Insects surviving the second treatment appeared to be those that were already inside the needles, that is, those that attacked in the time interval between bud burst and treatment. Gall formation, which begins immediately after attack, appeared to inhibit translocation of the insecticide to the infestation site.

The inability of acephate to significantly reduce the summer generation of *A. cooleyi* was disappointing. Even more disappointing was the discovery that the treatment eventually lead to increased populations in the winter generation. Many of the treated trees had the heaviest *A. cooleyi* populations we had ever seen. Apparently, acephate is more toxic to the predators (*A. cooleyi* has no parasites) than it is to the prey. And because immature predators (mostly syrphids and anthocorids) are most abundant on infested trees just after bud burst, the treatment at 60 percent bud burst was more disruptive than the treatment before bud burst. Any future tests with acephate on Douglas-fir will need a check to determine if *A. cooleyi* populations are released by the spray. This problem could negate any expected benefits from acephate in controlling the midge population.

Conclusion

If acephate has potential value against the Douglas-fir needle midge, and if we are going to realize that value, we still need to clarify three points. First, we should determine if acephate can be effectively applied from the air, since many Christmas tree farms in the Pacific Northwest are too large for ground-spray operations. Second, to add flexibility to control programs, it should be established how early before bud burst acephate can effectively be applied. Last, because the lowest treatment rate in this test was 99.8 percent effective, it is likely that the minimum dose could be reduced even more.

The occurrence of phytotoxicity was interesting but of no practical consequence to Christmas tree growers. Most control efforts against the gall midge would likely occur before bud burst and probably at a lower insecticide concentration than was used in this test. A lower dose may also solve the problem of resurging aphid populations.

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